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(54) **OUTER CASE WITH GUSSETED BOSS**

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(52) **U.S. Cl.**
CPC ***F01D 25/162*** (2013.01); ***F01D 25/24*** (2013.01)

(58) **Field of Classification Search**
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(56) **References Cited**

U.S. PATENT DOCUMENTS

2,217,081 A * 10/1940 Stough B60B 3/16 301/35.626
2,282,721 A * 5/1942 Hall F02B 75/26 123/193.1
2,596,465 A * 5/1952 Booth A47B 13/08 38/137
2,875,579 A * 3/1959 Gerdan F02C 7/20 60/726
4,050,241 A * 9/1977 DuBell F23M 5/085 60/757
4,652,244 A * 3/1987 Drury .... B63H 11/102 114/183 R
5,483,792 A * 1/1996 Czachor F01D 25/162 60/796
7,748,209 B1 * 7/2010 Schopf F01D 5/082 60/39.08
2003/0131603 A1 * 7/2003 Bolender F23R 3/002 60/772
2003/0189028 A1 * 10/2003 Wright B23K 9/048 219/76.12
2004/0069561 A1 * 4/2004 Cox H04R 1/02 181/199
2008/0276621 A1 * 11/2008 Somanath F01D 25/162 60/796
2010/0021286 A1 * 1/2010 Somanath F01D 25/162 415/126
2010/0125770 A1 5/2010 Keith, Jr.
2012/0163964 A1 * 6/2012 Chuong F01D 25/246 415/191
2012/0177490 A1 * 7/2012 Lussier F01D 25/28 415/213.1
2013/0224010 A1 * 8/2013 Farah F01D 25/162 415/209.2
2013/0224012 A1 * 8/2013 Durocher F01D 25/28 415/213.1

* cited by examiner

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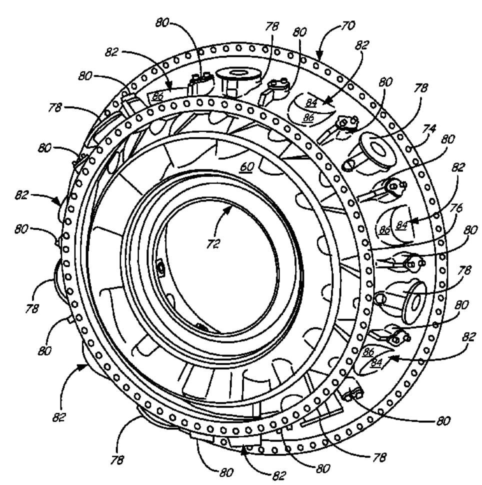
(57) **ABSTRACT**

An outer case employed in a gas turbine engine includes a plurality of support member bosses and a plurality of gusseted bosses. The plurality of support member bosses are disposed circumferentially around the outer case for receiving and securing support members that attach the outer case to an inner hub. The plurality of gusseted bosses are disposed circumferentially around the outer case and between the plurality of support member bosses.

17 Claims, 2 Drawing Sheets



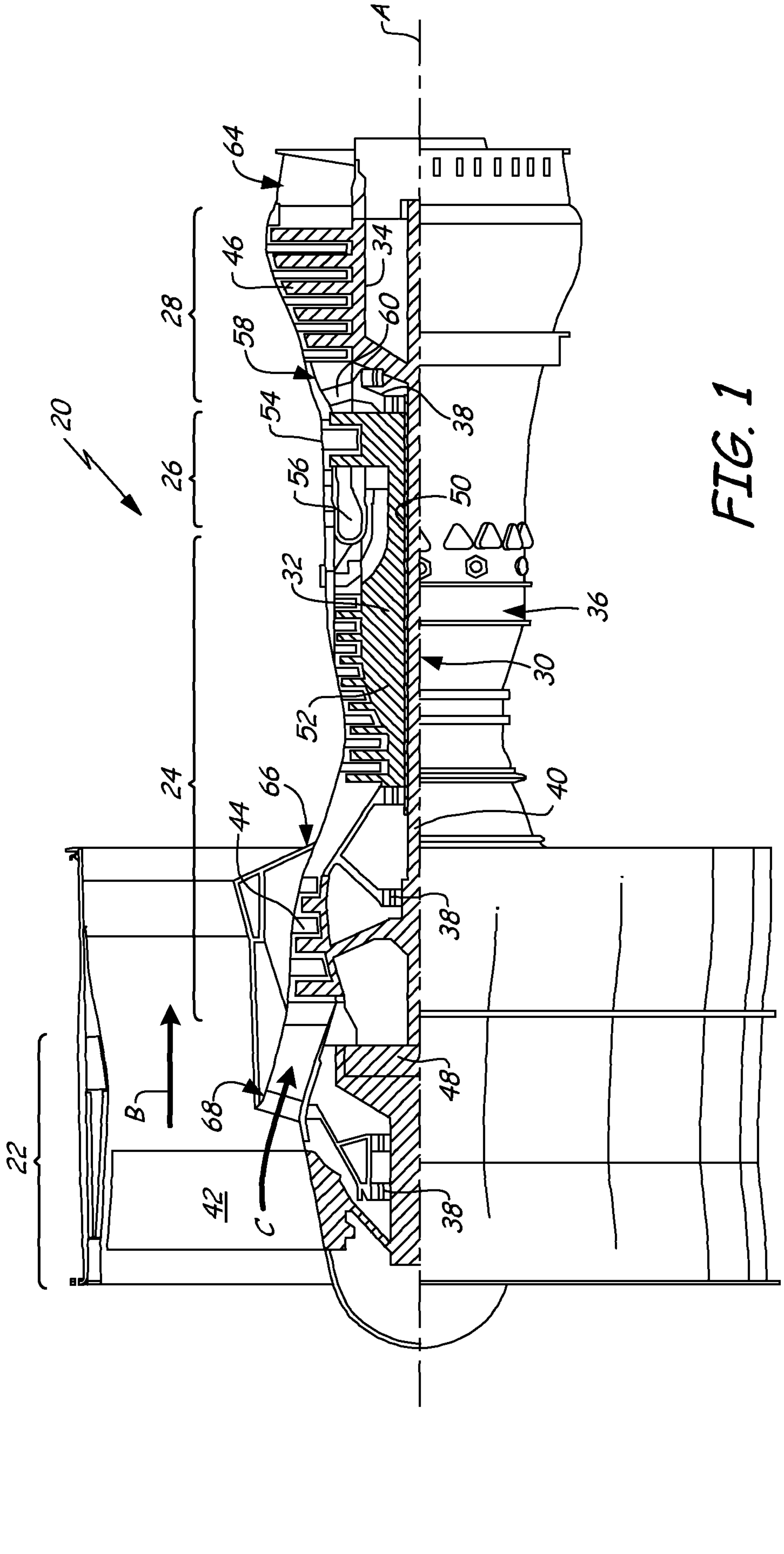

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FIG. 1

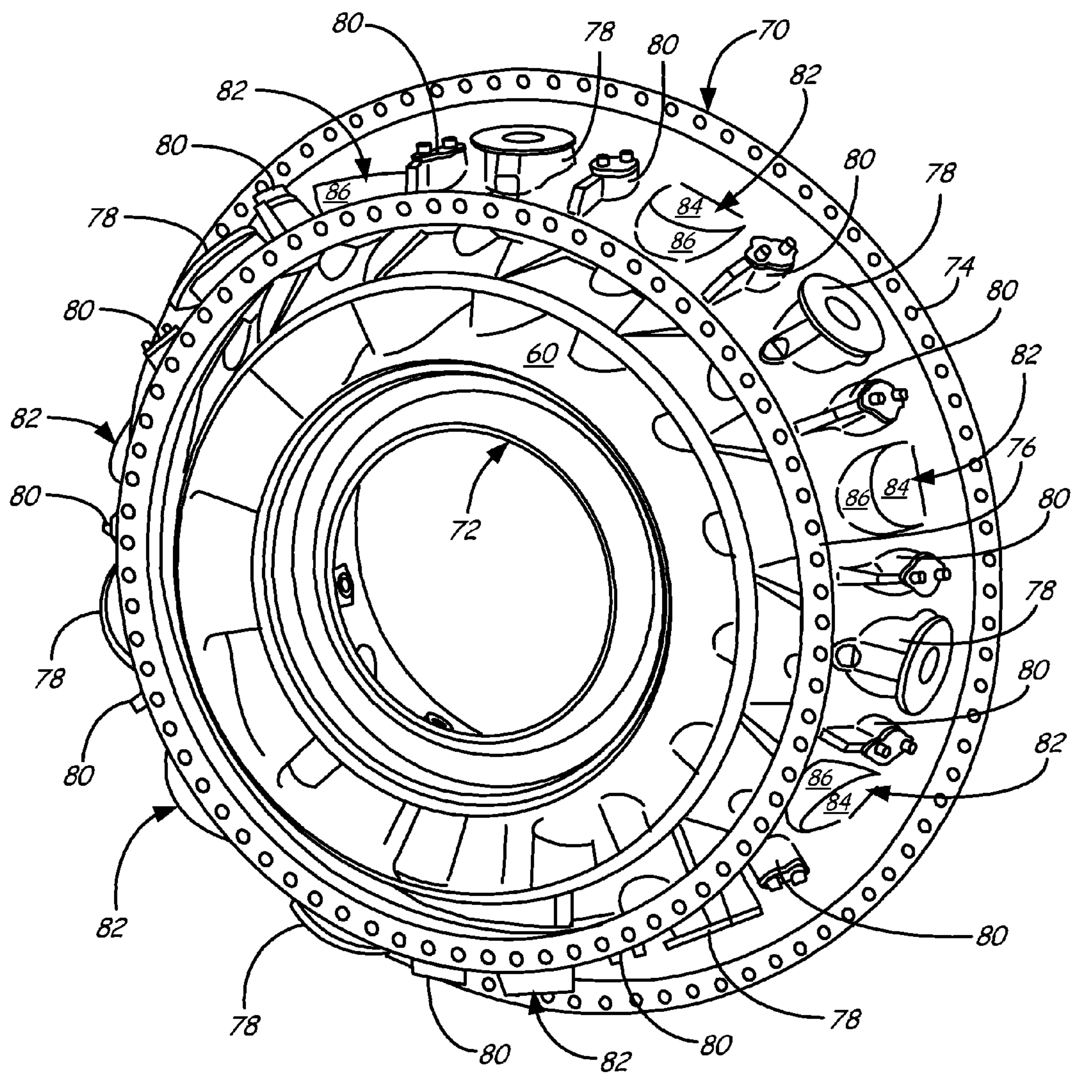
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FIG. 2

OUTER CASE WITH GUSSETED BOSS

BACKGROUND

The present invention is related to gas turbine engines, and in particular to the outer case of a gas turbine engine.

An outer engine case for a gas turbine engine includes multiple case sections that are secured to each other at flange connections The multiple case sections are required to facilitate installation of various internal gas turbine engine components such as a compressor assembly, combustor assembly, turbine assembly, and exhaust assembly. Typically, a number of outer case assemblies are employed, with the various outer case assemblies being bolted together at flanged joints. The outer case provides structural support for the various components of the gas turbine engine which are attached thereto. However, forces applied to the outer case can result in ovalization of the case, which is detrimental to the efficiency of the engine.

SUMMARY

An outer case employed in a gas turbine engine includes a plurality of support member bosses and a plurality of gusseted bosses. The plurality of support member bosses are disposed circumferentially around the outer case for receiving and securing support members that attach the outer case to an inner hub. The plurality of gusseted bosses are disposed circumferentially around the outer case and between the plurality of support member bosses.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** schematically illustrates an example gas turbine engine that includes a fan section, a compressor section, a combustor section and a turbine section.

FIG. **2** is a perspective view of an outer case according to an embodiment of the present invention.

DETAILED DESCRIPTION

FIG. **1** schematically illustrates an example gas turbine engine **20** that includes fan section **22**, compressor section **24**, combustor section **26** and turbine section **28**. Alternative engines might include an augmenter section (not shown) among other systems or features. Fan section **22** drives air along bypass flow path B while compressor section **24** draws air in along core flow path C where air is compressed and communicated to combustor section **26**. In combustor section **26**, air is mixed with fuel and ignited to generate a high pressure exhaust gas stream that expands through turbine section **28** where energy is extracted and utilized to drive fan section **22** and compressor section **24**.

Although the disclosed non-limiting embodiment depicts a turbofan gas turbine engine, it should be understood that the concepts described herein are not limited to use with turbofans as the teachings may be applied to other types of turbine engines; for example a turbine engine including a three-spool architecture in which three spools concentrically rotate about a common axis and where a low spool enables a low pressure turbine to drive a fan via a gearbox, an intermediate spool that enables an intermediate pressure turbine to drive a first compressor of the compressor section, and a high spool that enables a high pressure turbine to drive a high pressure compressor of the compressor section.

The example engine **20** generally includes low speed spool **30** and high speed spool **32** mounted for rotation about an engine central longitudinal axis A relative to outer case **36** via several bearing systems **38**. It should be understood that various bearing systems **38** at various locations may alternatively or additionally be provided. As discussed in more detail with respect to FIG. **2**, a plurality of gusseted bosses may be disposed circumferentially around outer case **36** at various axial locations in order to maintain system stiffness symmetry, thereby controlling ovalization and centerline shift.

Low speed spool **30** generally includes inner shaft **40** that connects fan **42** and low pressure (or first) compressor section **44** to low pressure (or first) turbine section **46**. Inner shaft **40** drives fan **42** through a speed change device, such as geared architecture **48**, to drive fan **42** at a lower speed than low speed spool **30**. High-speed spool **32** includes outer shaft **50** that interconnects high pressure (or second) compressor section **52** and high pressure (or second) turbine section **54**. Inner shaft **40** and outer shaft **50** are concentric and rotate via bearing systems **38** about engine central longitudinal axis A.

Combustor **56** is arranged between high pressure compressor **52** and high pressure turbine **54**. In one example, high pressure turbine **54** includes at least two stages to provide a double stage high pressure turbine **54**. In another example, high pressure turbine **54** includes only a single stage. As used herein, a “high pressure” compressor or turbine experiences a higher pressure than a corresponding “low pressure” compressor or turbine.

The example low pressure turbine **46** has a pressure ratio that is greater than about 5. The pressure ratio of the example low pressure turbine **46** is measured prior to an inlet of low pressure turbine **46** as related to the pressure measured at the outlet of low pressure turbine **46** prior to an exhaust nozzle.

Mid-turbine frame **58** of engine static structure **36** is arranged generally between high pressure turbine **54** and low pressure turbine **46**. Mid-turbine frame **58** further supports bearing systems **38** in turbine section **28** as well as setting airflow entering low pressure turbine **46**. As discussed in more detail with respect to FIG. **2**, an outer case portion of mid-turbine frame **58** includes a plurality of gusseted bosses disposed circumferentially around the outer case to prevent ovalization due to forces communicated to the outer case from bearing assemblies **38**.

The core airflow C is compressed by low pressure compressor **44** then by high pressure compressor **52** mixed with fuel and ignited in combustor **56** to produce high speed exhaust gases that are then expanded through high pressure turbine **54** and low pressure turbine **46**. Mid-turbine frame **58** includes vanes **60**, which are in the core airflow path and function as an inlet guide vane for low pressure turbine **46**. Utilizing vane **60** of mid-turbine frame **58** as the inlet guide vane for low pressure turbine **46** decreases the length of low pressure turbine **46** without increasing the axial length of mid-turbine frame **58**. Reducing or eliminating the number of vanes in low pressure turbine **46** shortens the axial length of turbine section **28**. Thus, the compactness of gas turbine engine **20** is increased and a higher power density may be achieved.

The disclosed gas turbine engine **20** in one example is a high-bypass geared aircraft engine. In a further example, gas turbine engine **20** includes a bypass ratio greater than about six (6), with an example embodiment being greater than about ten (10). The example geared architecture **48** is an epicyclical gear train, such as a planetary gear system, star gear system or other known gear system, with a gear reduction ratio of greater than about 2.3.

In one disclosed embodiment, gas turbine engine **20** includes a bypass ratio greater than about ten (10:1) and the fan diameter is significantly larger than an outer diameter of low pressure compressor **44**. It should be understood, however, that the above parameters are only exemplary of one embodiment of a gas turbine engine including a geared architecture and that the present disclosure is applicable to other gas turbine engines.

FIG. **2** is a perspective view of outer case **70** according to an embodiment of the present invention. In the embodiment shown in FIG. **2**, outer case **70** is employed in a mid-turbine frame **58**, discussed above with respect to FIG. **1**, which in addition to outer case **70** includes vanes **60** (shown in FIG. **1**) and inner hub **72** (not shown in FIG. **1**). Although described with respect to mid-turbine frame **58**, gusseted bosses may be employed with respect to any portion of the outer case in which ovalization control is desired.

Outer case **70** includes flanges **74** and **76** for connection to fore and aft case assemblies (not shown). Outer case further includes a plurality of support member bosses **78** disposed circumferentially around outer case **70** for receiving and securing support structures such as struts/rods that communicate forces from inner hub **72** to outer case **70**. Additionally, a number of borescope plug/pin bosses **80** are similarly disposed circumferentially around outer case **70** that allow for insertion of a borescope for inspection of vanes **60**. Although not shown in FIG. **2**, additional bosses may be disposed circumferentially around the outer case to allow for the receiving and securing of oil service tubes that pass through inner but **72** and connect to the bearing housing.

In addition, a plurality of gusseted bosses **82** are disposed circumferentially around outer case **70**, and between support member bosses **78** and/or borescope/plug bosses **80**. In the embodiment shown in FIG. **2**, each gusseted boss **82** is axially aligned with support member bosses **78** and borescope plug/pin bosses **80**. None of the gusseted bosses **82** are associated with a support member or other connection to the outer case. Rather, each gusseted boss **82** is utilized for the sole purpose of maintaining system stiffness symmetry, thereby controlling ovalization and centerline shift.

The number and position of the gusseted bosses **82** act to balance stiffness provided by the main stiffness drivers such as outer case **70**, inner hub **72**, and the struts/rods connecting the outer case to the inner hub, with induced forces generated for example, by bearing loads, gearbox link loads, oil tank loads, and oil service tubes to provide equal system stiffness symmetry. For example, in the embodiment shown in FIG. **2**, seven gusseted bosses are disposed on outer case **70**, located between borescope plug/pin bosses **80**.

Each gusseted boss **82** includes flat portion **84** is approximately parallel to the engine centerline axis A, and curved portion **86** that is substantially perpendicular to flat portion **84** and engine centerline axis A. In one embodiment, the interior of gusseted boss **82** includes a hollow portion (not shown) formed by flat portion **84** and curved portion **86**, which reduces the weight of outer case **70** without affecting the load bearing capability of outer case **70**. In particular, the geometry of gusseted bosses **82**, and the placement of bosses **82** circumferentially around outer case **70**, provides additional stiffness to outer case **70** that resists or prevents ovalization of outer case **70** in response to forces applied via support member bosses **78**.

In an exemplary embodiment, an outer case employed in a gas turbine engine includes a plurality of support member bosses and a plurality of gusseted bosses. The plurality of support member bosses are disposed circumferentially around the outer case for receiving and securing support members that attach the outer case to an inner hub. The

plurality of gusseted bosses are disposed circumferentially around the outer case and between the plurality of support member bosses.

In one embodiment, each of the plurality of gusseted bosses may include a flat portion extending from the outer case that is substantially parallel to an engine centerline axis and a curved portion extending between the outer case and the flat portion that is substantially perpendicular to the flat portion.

In another embodiment, each of the plurality of gusseted bosses may be axially aligned with the support member bosses.

In another embodiment, the outer case may be associated with a mid-turbine frame portion of the gas turbine engine.

In another embodiment, the plurality of gusseted bosses are located to maintain system stiffness symmetry.

In another embodiment, the plurality of gusseted bosses are located circumferentially around the outer case to provide ovalization control of the outer case.

In another embodiment, seven gusseted bosses are disposed circumferentially around the outer case.

In an exemplary embodiment, a mid-turbine employed in a gas turbine engine includes an inner hub, an outer case, a plurality of vanes located in a gas path defined between the inner hub and the outer case, and a plurality of support members affixed between the inner hub and the outer case that transfer loads from the inner hub to the outer case. The outer case includes a plurality of support member bosses that receive and affix the support members to the outer case and a plurality of gusseted bosses disposed circumferentially around the outer case and between the plurality of support member bosses.

In one embodiment, the plurality of gusseted bosses may include a flat portion extending from the outer case that is substantially parallel to an engine centerline axis and a curved portion extending between the outer case and the flat portion that is substantially perpendicular to the flat portion.

In another embodiment, the plurality of gusseted bosses may be axially aligned with the support member bosses.

In another embodiment, the plurality of gusseted bosses are located to maintain system stiffness symmetry.

In another embodiment, the plurality of gusseted bosses are located circumferentially around the outer case to provide ovalization control of the outer case.

In another embodiment, seven gusseted bosses are disposed circumferentially around the outer case.

In an exemplary embodiment, a gas turbine engine includes a fan section, a compressor section located downstream from the fan section, a combustor section, a high pressure turbine section located downstream from the combustor section, a low pressure turbine section located downstream for the high pressure turbine section, and a mid-turbine frame section disposed between the high pressure turbine section and the low pressure section. The mid-turbine frame section includes an inner hub, an outer case, a plurality of vanes located in a gas path defined between the inner hub and the outer case, and a plurality of support members affixed between the inner hub and the outer case that transfer loads from the inner hub to the outer case. The outer case includes a plurality of support member bosses that receive and affix the support members to the outer case and a plurality of gusseted bosses disposed circumferentially around the outer case and between the plurality of support member bosses.

In one embodiment, the plurality of gusseted bosses may include a flat portion extending from the outer case that is substantially parallel to an engine centerline axis and a curved portion extending between the outer case and the flat portion that is substantially perpendicular to the flat portion.

In another embodiment, the plurality of gusseted bosses may be axially aligned with the support member bosses.

In another embodiment, the plurality of gusseted bosses are located to maintain system stiffness symmetry.

In another embodiment, the plurality of gusseted bosses are located circumferentially around the outer case to provide ovalization control of the outer case.

In another embodiment, seven gusseted bosses are disposed circumferentially around the outer case.

In this way, the present invention describes the use of gusseted bosses to provide ovalization control of an outer case in a gas turbine engine. Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

The invention claimed is:

1. An outer case employed in a gas turbine engine, the outer case comprising:

a plurality of support member bosses disposed circumferentially around the outer case for receiving and securing support members that attach the outer case to an inner hub; and

a plurality of gusseted bosses disposed circumferentially around the outer case and between the plurality of support member bosses, wherein each of the plurality of gusseted bosses is solid and is solely connected to a single surface of the outer case.

2. The outer case of claim **1**, wherein each of the plurality of gusseted bosses include:

a flat portion extending from the surface of the outer case that is substantially parallel to an engine centerline axis; and

a curved portion extending between the surface of the outer case and the flat portion that is substantially perpendicular to the flat portion.

3. The outer case of claim **1**, wherein the plurality of gusseted bosses are axially aligned with the support member bosses.

4. A mid-turbine frame portion of a gas turbine engine comprising the outer case of claim **1**.

5. The outer case of claim **1**, wherein the plurality of gusseted bosses are located to maintain system stiffness symmetry.

6. The outer case of claim **1**, wherein the plurality of gusseted bosses are located circumferentially around the outer case to provide ovalization control of the outer case.

7. The outer case of claim **1**, wherein seven gusseted bosses are disposed circumferentially around the outer case.

8. A mid-turbine frame comprising:

an inner hub;

an outer case;

a plurality of vanes located in a gas path defined between the inner hub and the outer case;

a plurality of support members affixed between the inner hub and the outer case that transfer loads from the inner hub to the outer case;

wherein the outer case includes:

a plurality of support member bosses that receive and affix the support members to the outer case; and

a plurality of gusseted bosses disposed circumferentially around the outer case and between the plurality of support member bosses, wherein each of the plurality of gusseted bosses is solid and is solely connected to a single surface of the outer case.

9. The mid-turbine frame of claim **8**, wherein each of the plurality of gusseted bosses include:

a flat portion extending from the surface of the outer case that is substantially parallel to an engine centerline axis; and

a curved portion extending between the surface of the outer case and the flat portion that is substantially perpendicular to the flat portion.

10. The mid-turbine frame of claim **8**, wherein the plurality of gusseted bosses are axially aligned with the support member bosses.

11. The mid-turbine frame of claim **8**, wherein the plurality of gusseted bosses are positioned circumferentially around the outer case to provide ovalization control of the outer case.

12. The mid-turbine frame of claim **8**, wherein seven gusseted bosses are disposed circumferentially around the outer case.

13. A gas turbine engine comprising:

a fan section;

a compressor section located downstream from the fan section;

a combustor section;

a high pressure turbine section located downstream from the combustor section;

a low pressure turbine section located downstream for the high pressure turbine section;

a mid-turbine frame section disposed between the high pressure turbine section and the low pressure section, the mid-turbine frame section comprising:

an inner hub;

an outer case;

a plurality of vanes located in a gas path defined between the inner hub and the outer case;

a plurality of support members affixed between the inner hub and the outer case that transfer loads from the inner hub to the outer case;

wherein the outer case includes:

a plurality of support member bosses that receive and affix the support members to the outer case; and

a plurality of gusseted bosses disposed circumferentially around the outer case and between the plurality of support member bosses, wherein each of the plurality of gusseted bosses is solid and is solely connected to a single surface of the outer case.

14. The gas turbine engine of claim **13**, wherein each of the plurality of gusseted bosses include:

a flat portion extending from the surface of the outer case that is substantially parallel to an engine centerline axis; and

a curved portion extending between the surface of the outer case and the flat portion that is substantially perpendicular to the flat portion.

15. The gas turbine engine of claim **13**, wherein the plurality of gusseted bosses are axially aligned with the support member bosses.

16. The gas turbine engine of claim **13**, wherein the plurality of gusseted bosses are positioned circumferentially around the outer case to provide ovalization control of the outer case.

17. The gas turbine engine of claim **13**, wherein seven gusseted bosses are disposed circumferentially around the outer case.

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